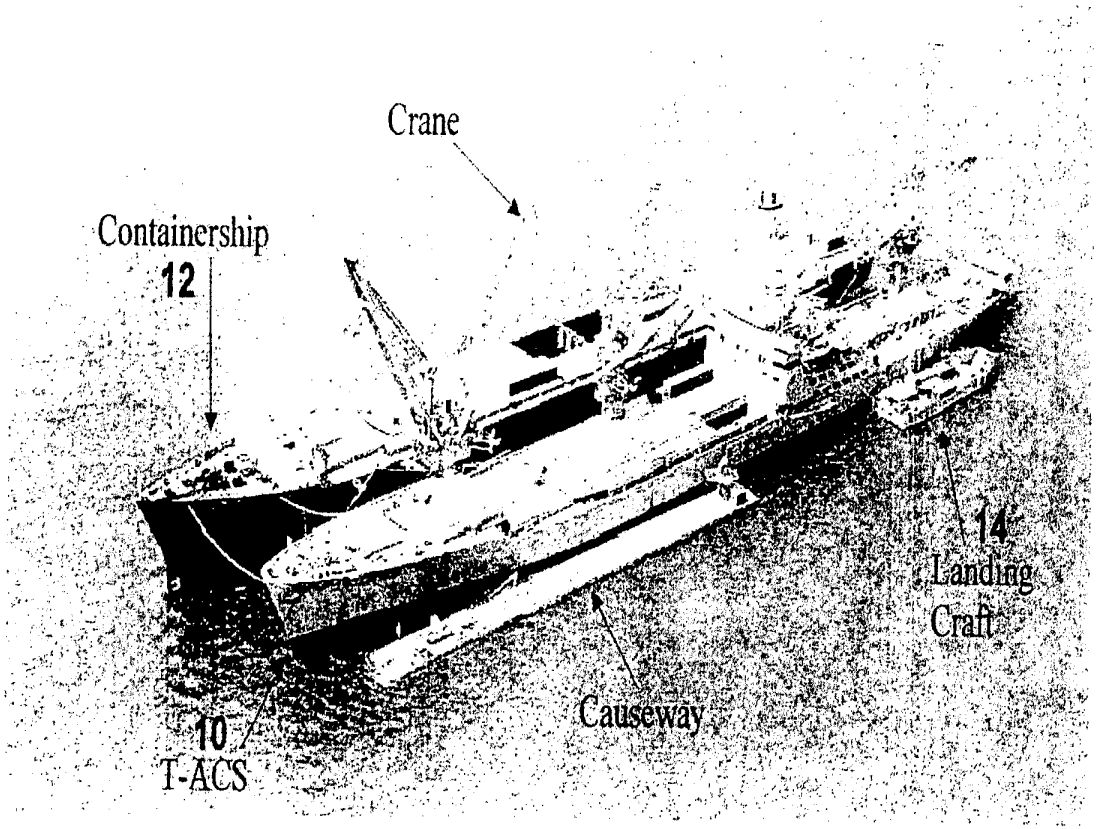


FIG. 1

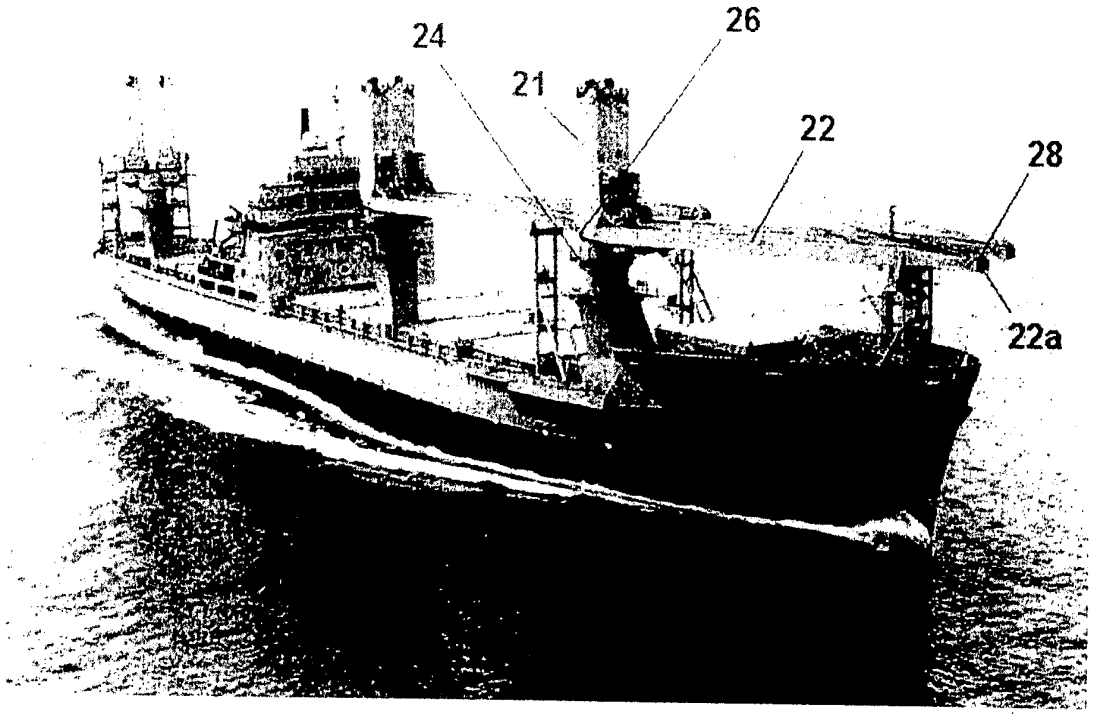


FIG. 2

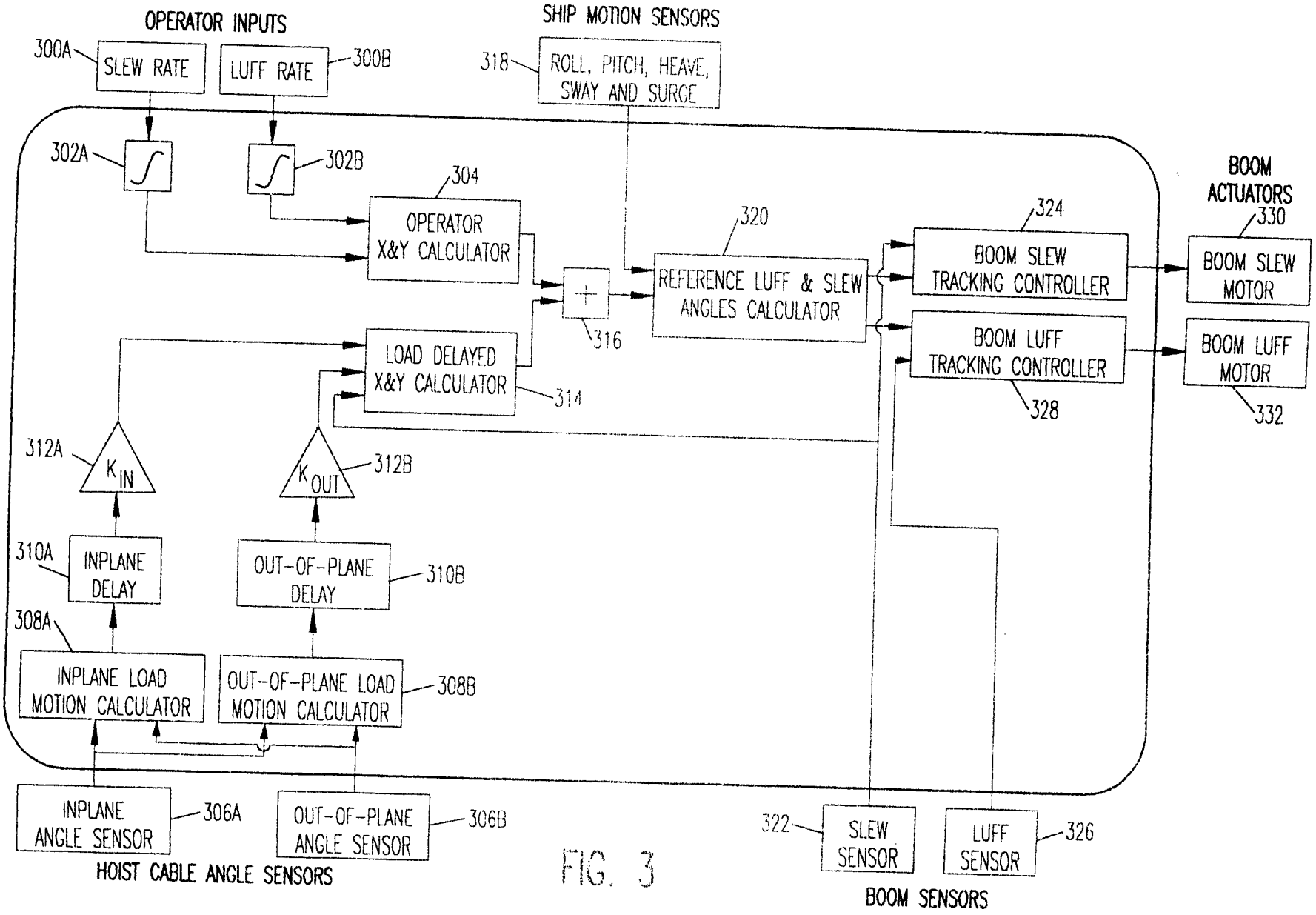

OPERATOR INPUTS
300A
SLEW RATE
LUFF RATE
300B
SHIP MOTION SENSORS
318
ROLL, PITCH, HEAVE, SWAY AND SURGE
302A
302B
304
OPERATOR X&Y CALCULATOR
320
REFERENCE LUFF & SLEW ANGLES CALCULATOR
316
324
BOOM SLEW TRACKING CONTROLLER
BOOM ACTUATORS
330
BOOM SLEW MOTOR
BOOM LUFF TRACKING CONTROLLER
328
BOOM LUFF MOTOR
332
LOAD DELAYED X&Y CALCULATOR
314
312A
K_{IN}
K_{OUT}
312B
310A
INPLANE DELAY
OUT-OF-PLANE DELAY
310B
308A
INPLANE LOAD MOTION CALCULATOR
OUT-OF-PLANE LOAD MOTION CALCULATOR
308B
INPLANE ANGLE SENSOR
306A
OUT-OF-PLANE ANGLE SENSOR
306B
HOIST CABLE ANGLE SENSORS
322
SLEW SENSOR
LUFF SENSOR
326
BOOM SENSORS

FIG. 3

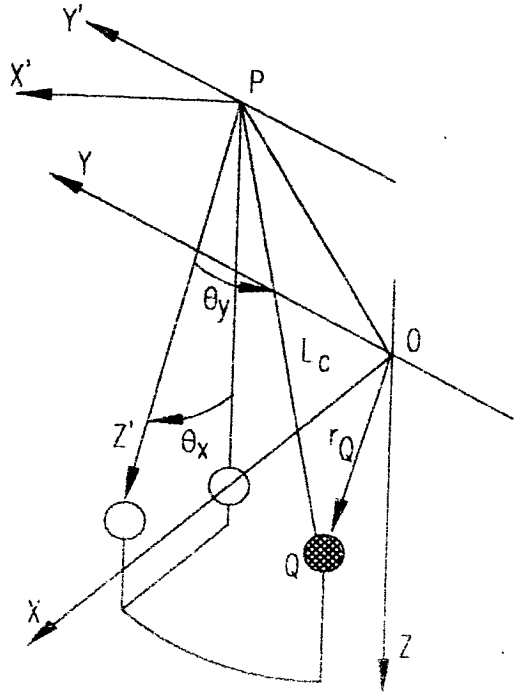


FIG. 4

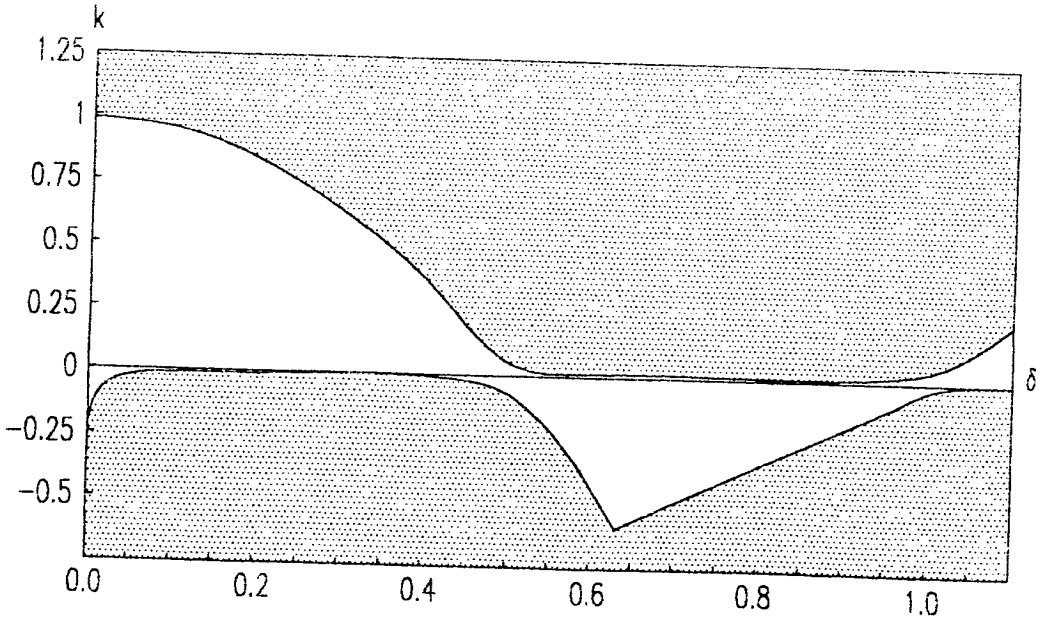


FIG. 5

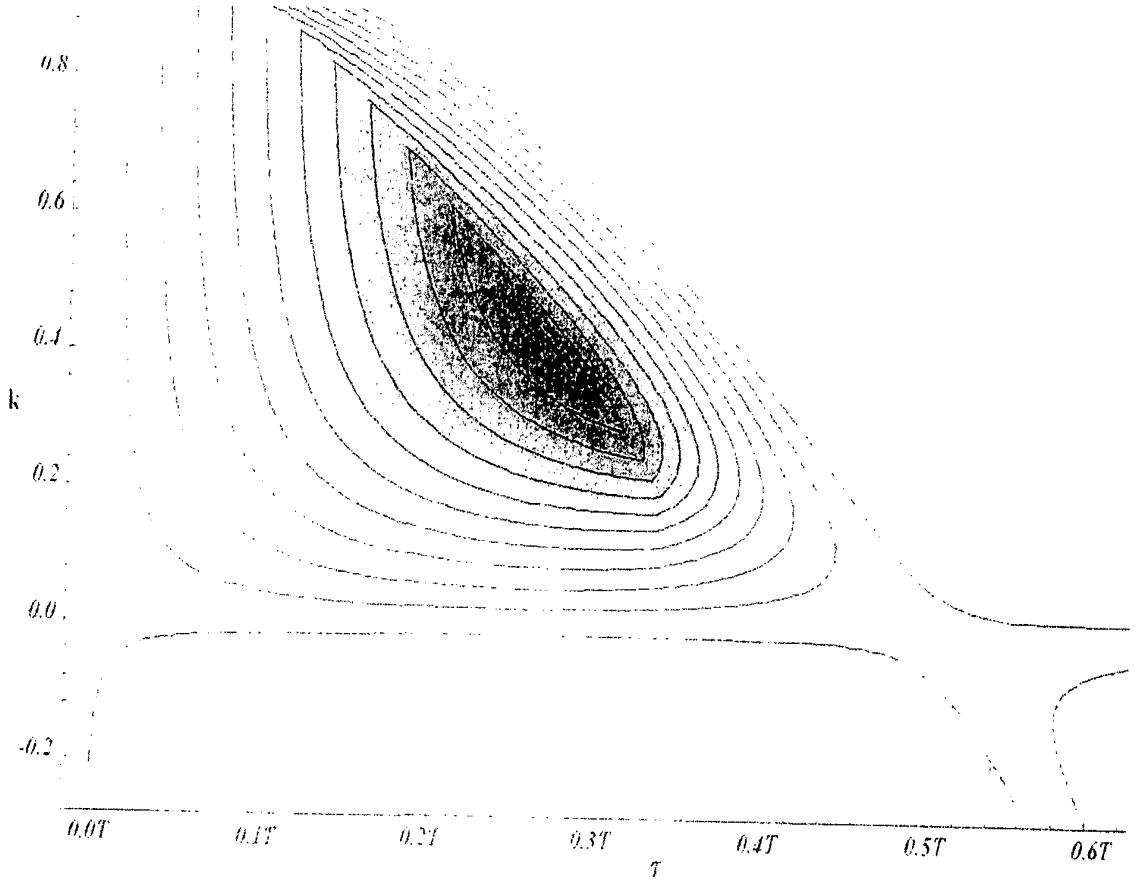


FIG. 6

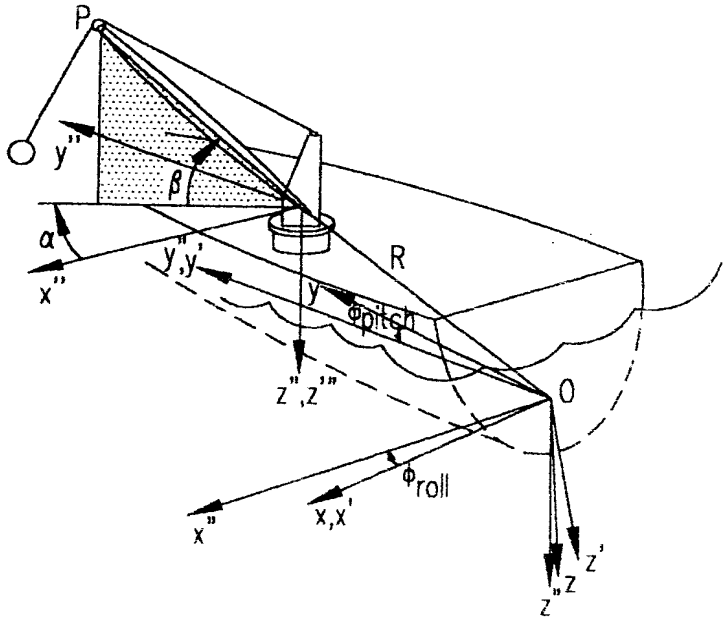


FIG. 7

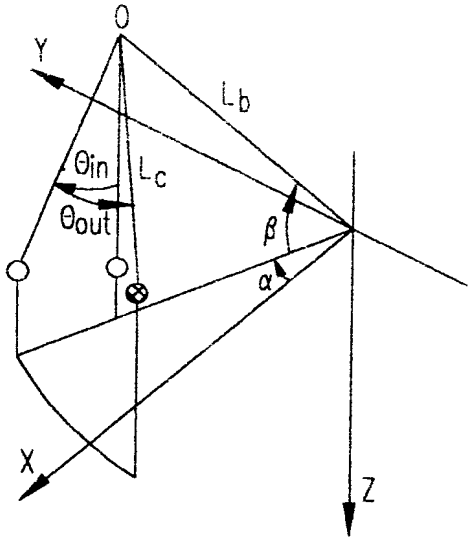


FIG. 8

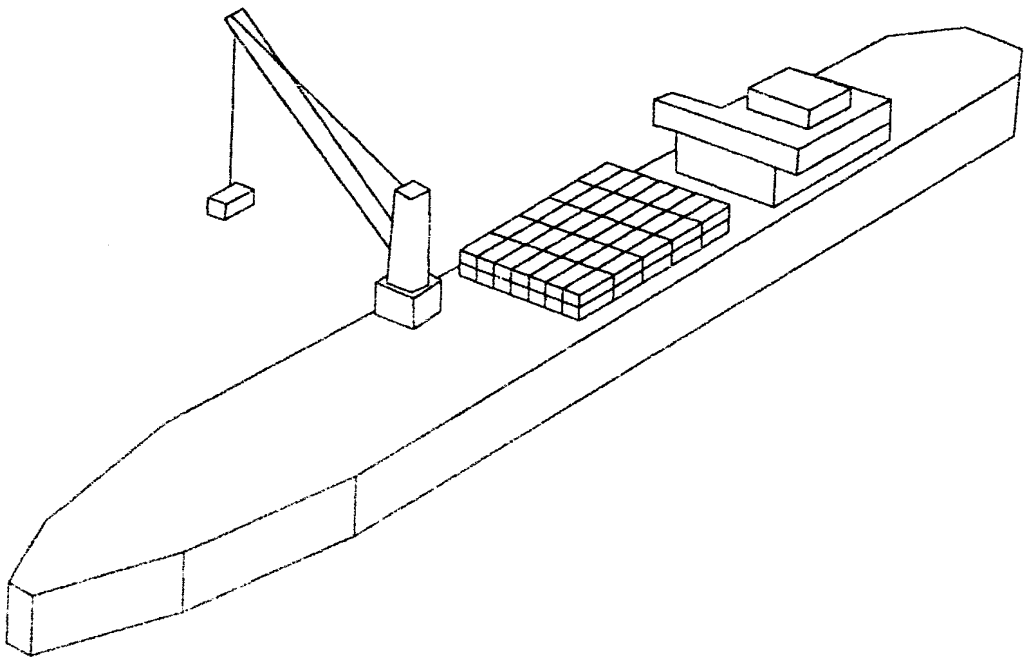


FIG. 9

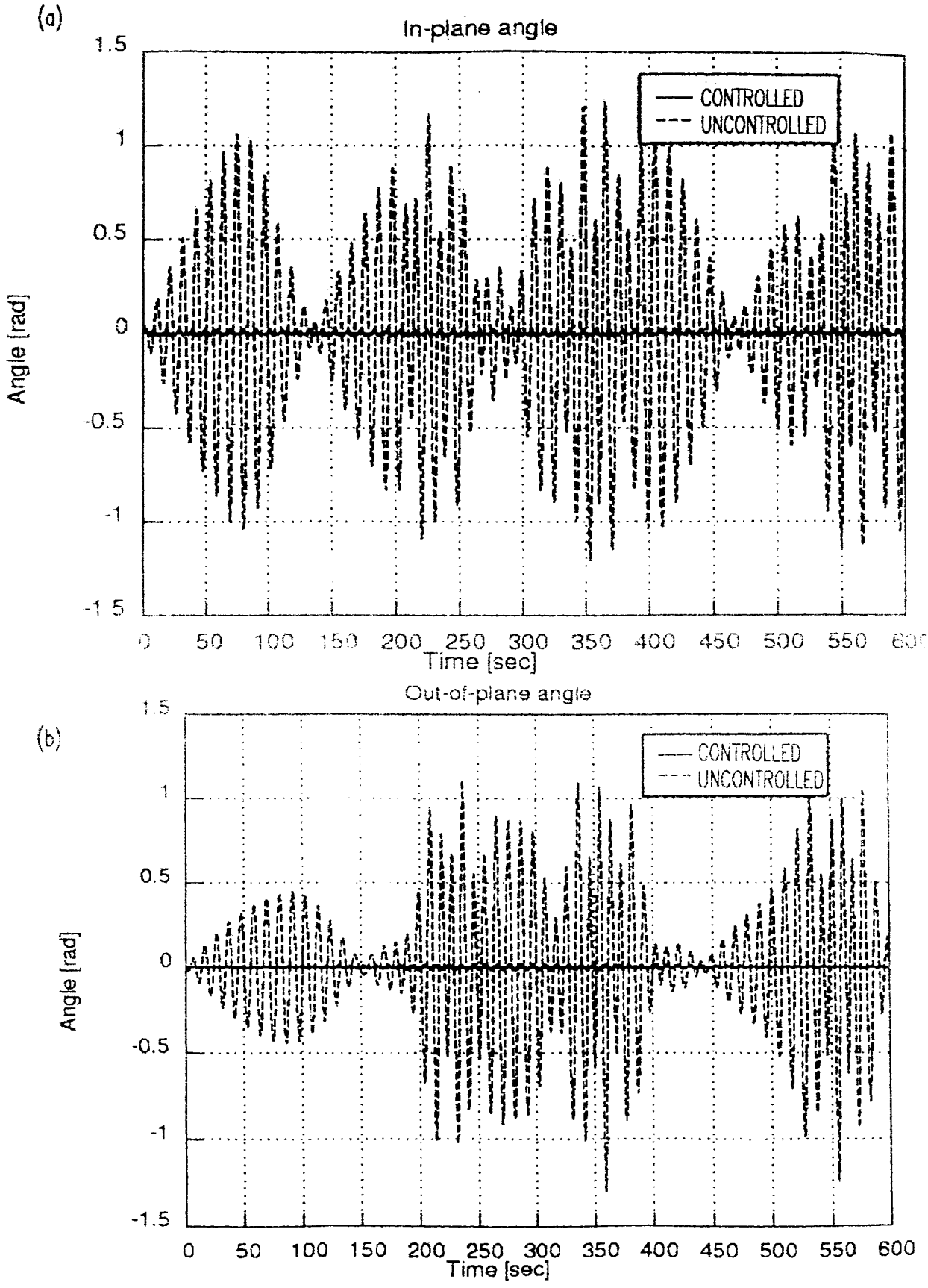
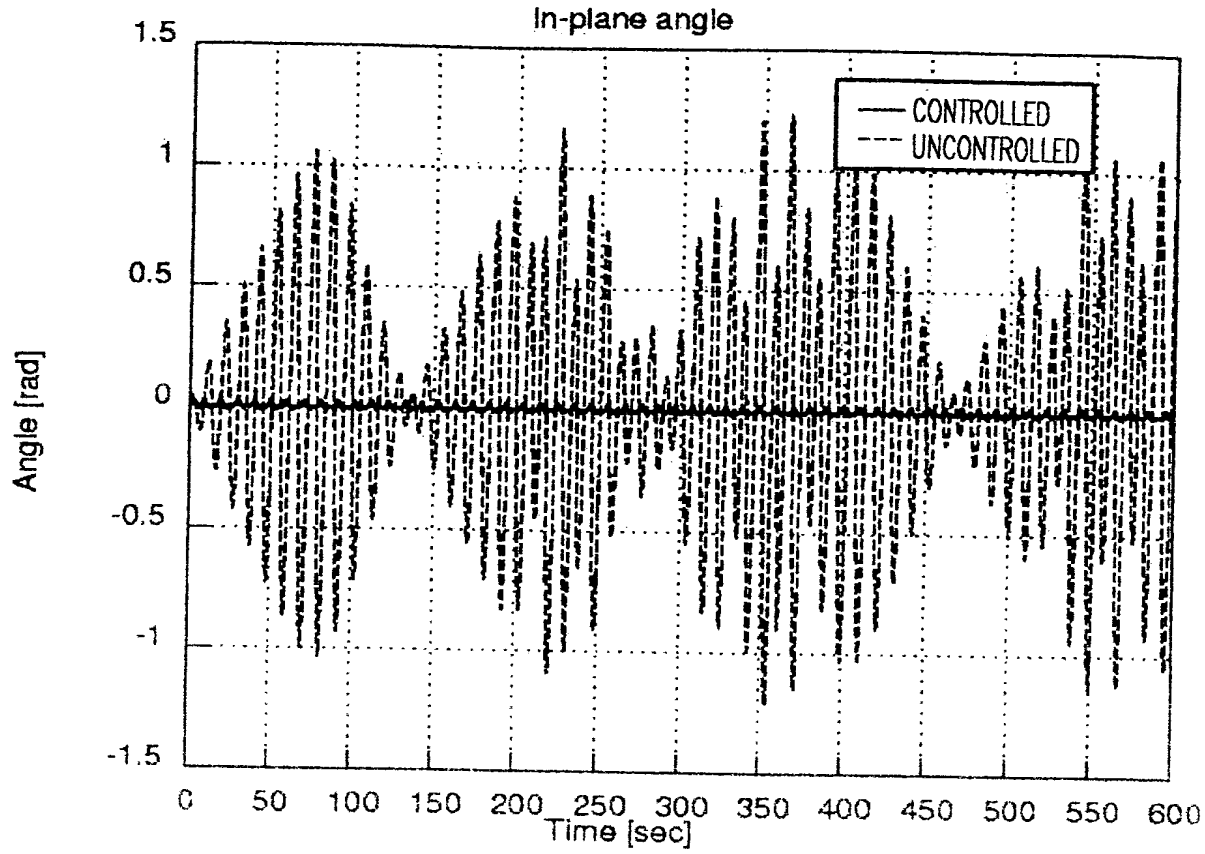

(a)
In-plane angle
CONTROLLED
UNCONTROLLED
Angle [rad]
Time [sec]
(b)
Out-of-plane angle
CONTROLLED
UNCONTROLLED
Angle [rad]
Time [sec]

FIG. 10

(a)


In-plane angle
CONTROLLED
UNCONTROLLED
Angle [rad]
1.5
1
0.5
0
-0.5
-1
-1.5
0
50
100
150
200
250
300
350
400
450
500
550
600
Time [sec]

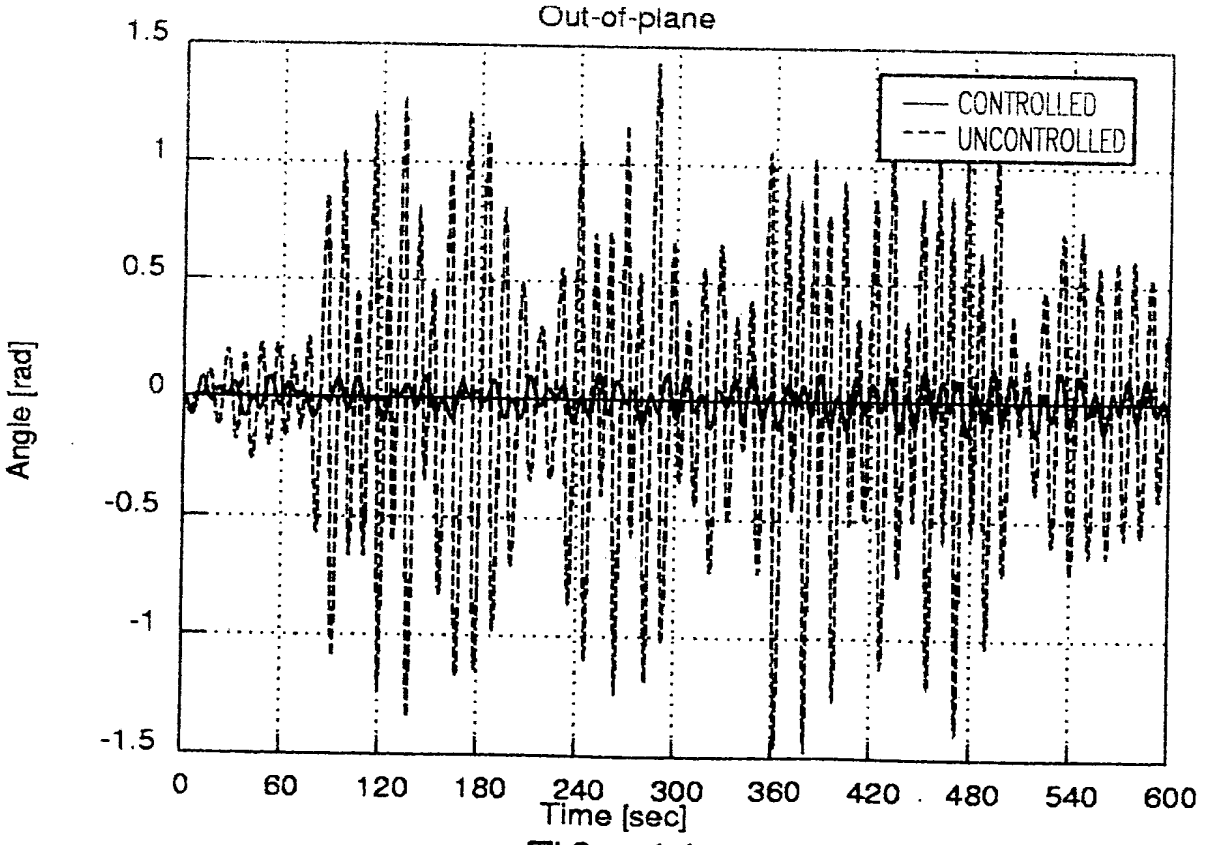

Out-of-plane
CONTROLLED
UNCONTROLLED
Angle [rad]
1.5
1
0.5
0
-0.5
-1
-1.5
0
60
120
180
240
300
360
420
480
540
600
Time [sec]

FIG. 11

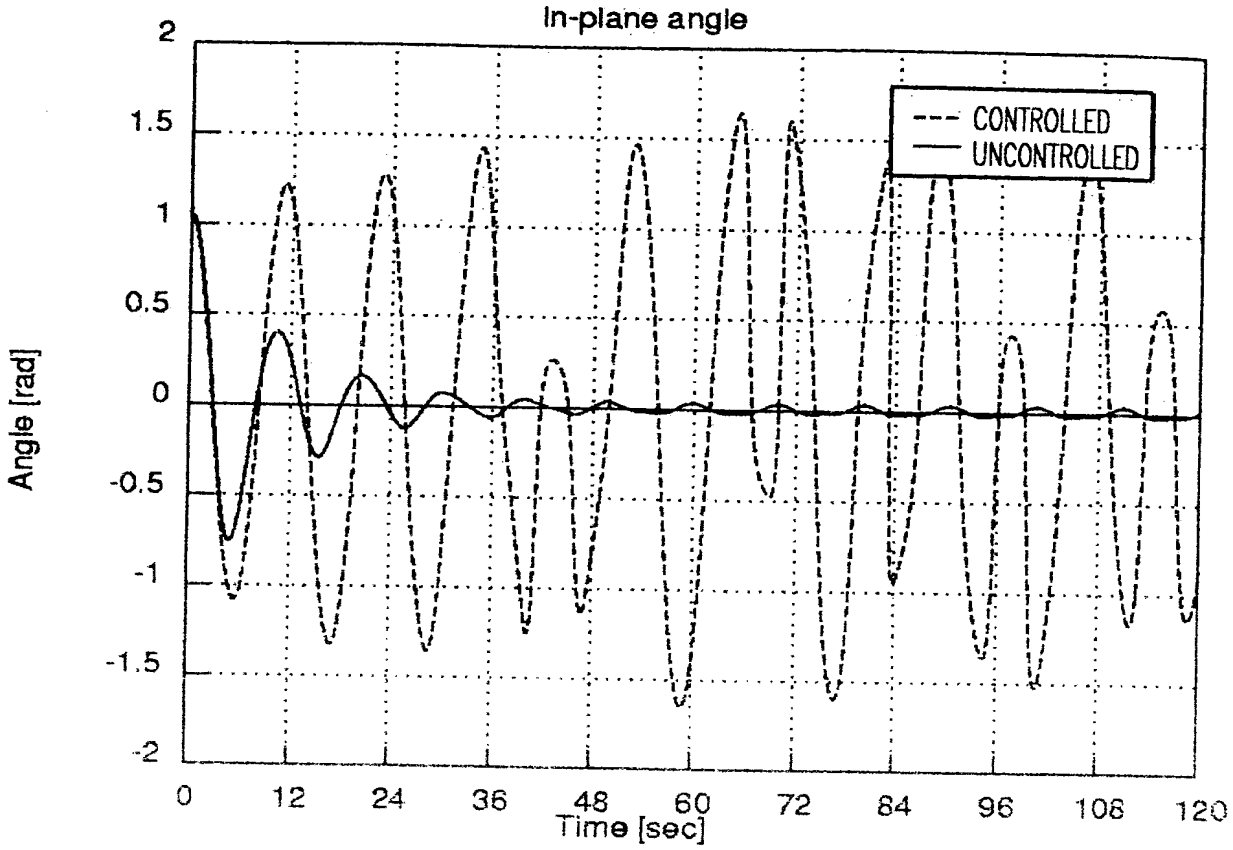

In-plane angle
CONTROLLED
UNCONTROLLED
Angle [rad]
Time [sec]
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
12
24
36
48
60
72
84
96
108
120

FIG. 12

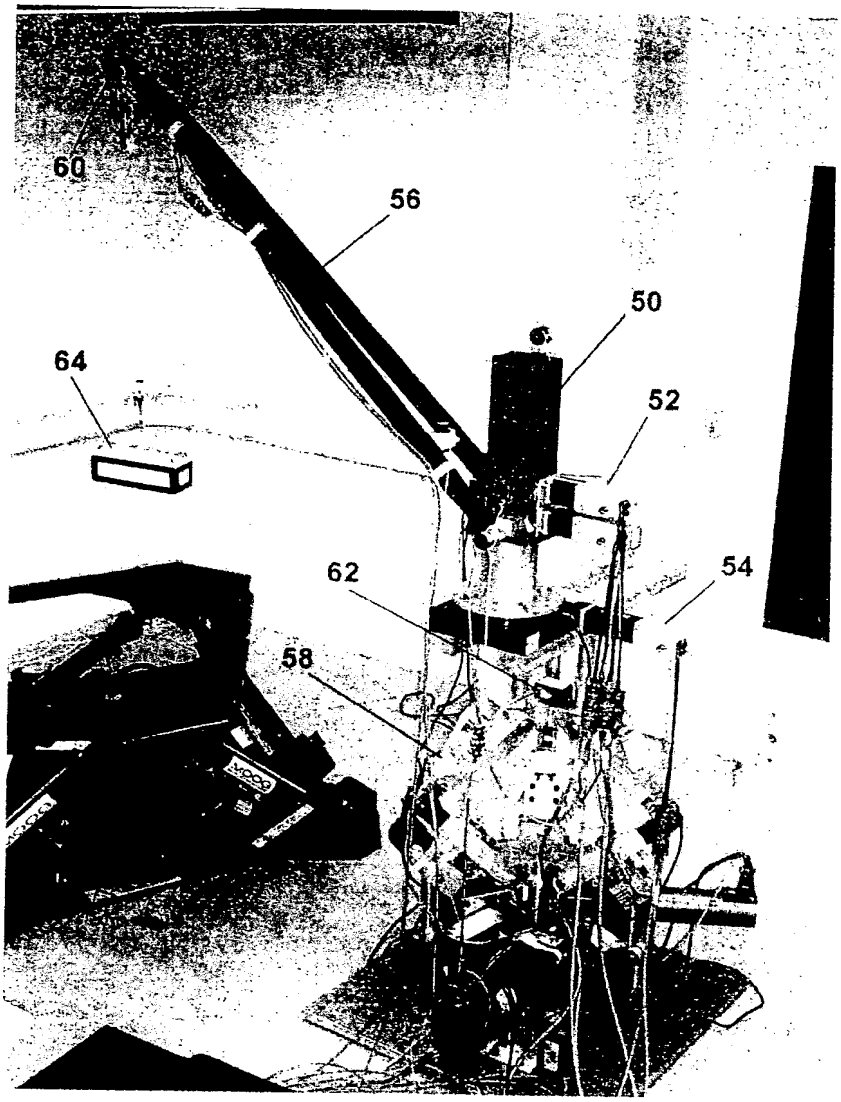


FIG. 13

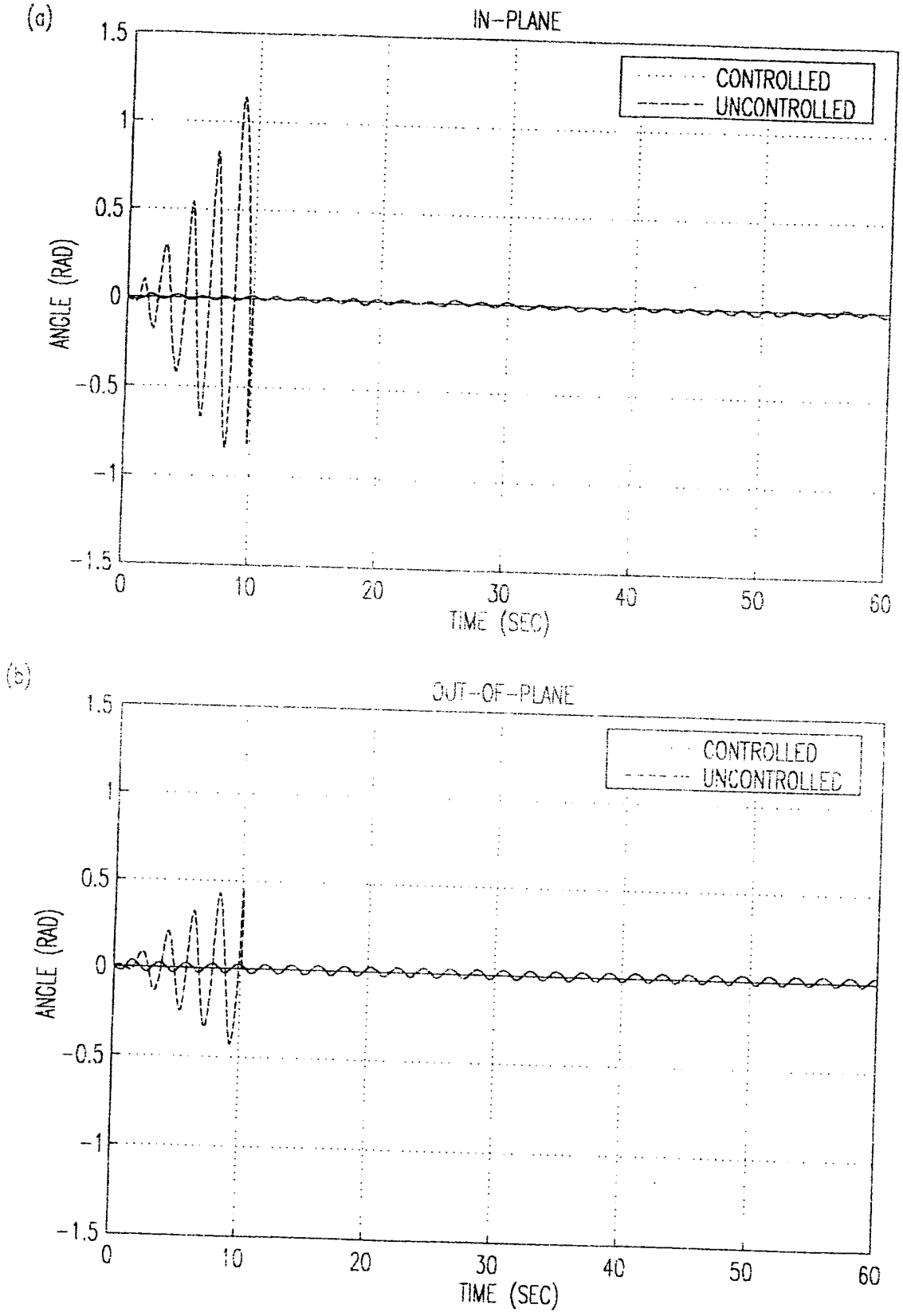

(a)
IN-PLANE
CONTROLLED
UNCONTROLLED
ANGLE (RAD)
TIME (SEC)
(b)
OUT-OF-PLANE
CONTROLLED
UNCONTROLLED
ANGLE (RAD)
TIME (SEC)

FIG. 14

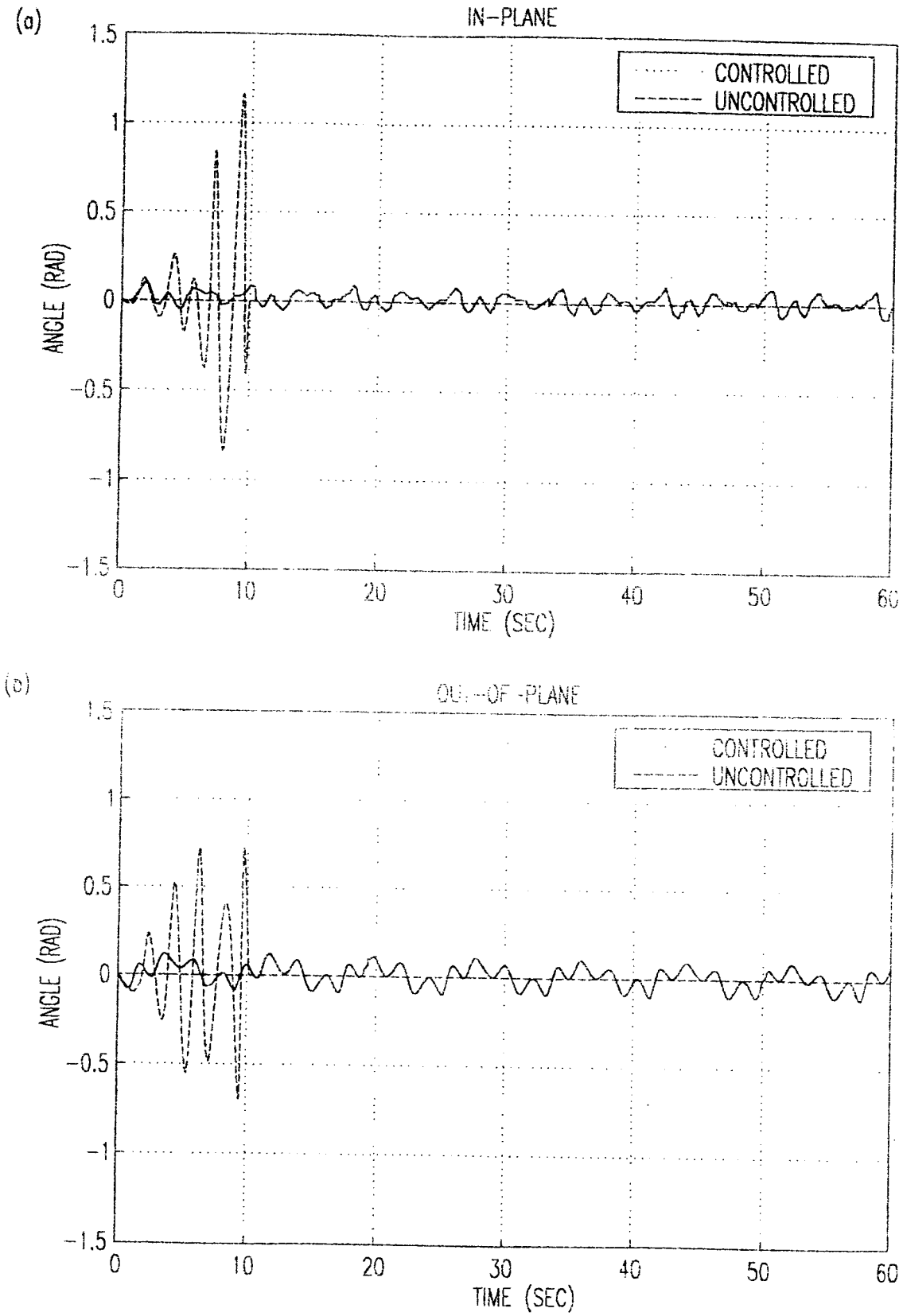

(a)
IN-PLANE
CONTROLLED
UNCONTROLLED
ANGLE (RAD)
TIME (SEC)
(b)
OUT-OF-PLANE
CONTROLLED
UNCONTROLLED
ANGLE (RAD)
TIME (SEC)

FIG. 15

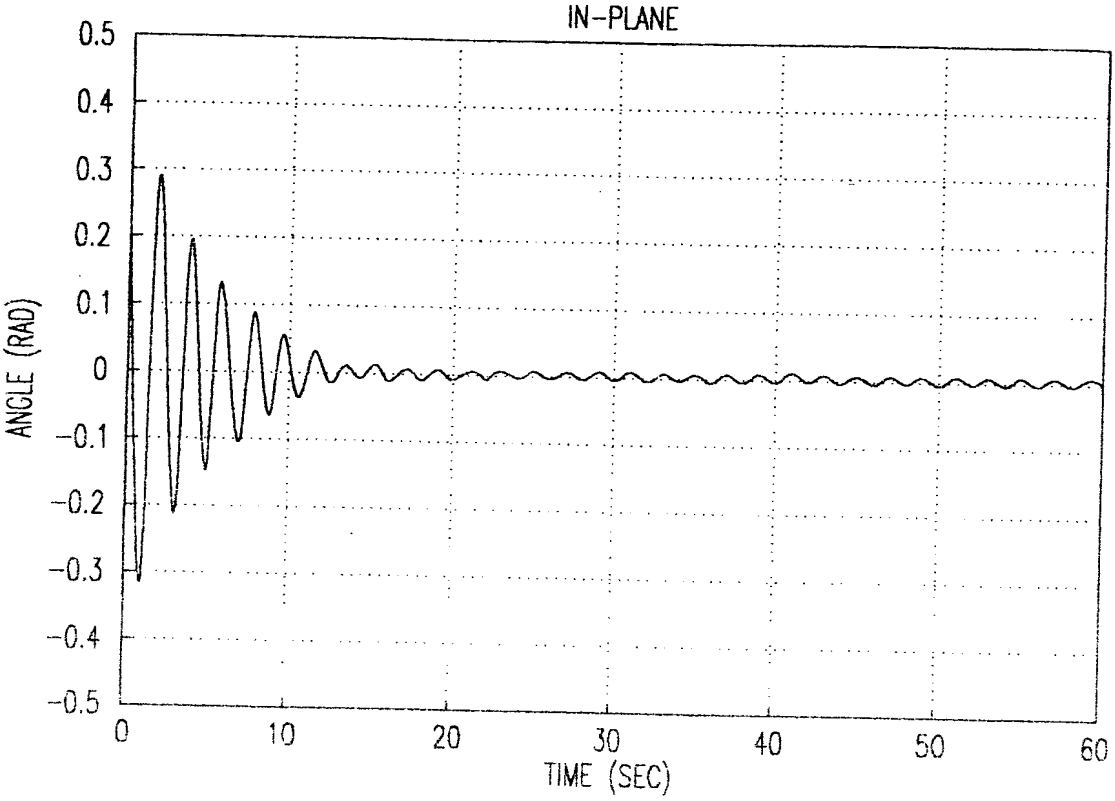

IN-PLANE
ANGLE (RAD)
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
0
10
20
30
40
50
60
TIME (SEC)

FIG. 16